

BROOKHAVEN NATIONAL LABORATORY Safety & Health Services Division INDUSTRIAL HYGIENE GROUP Standard Operating Procedure: Field Procedure	NUMBER IH99380
	REVISION FINAL rev 1
SUBJECT: INSTRUMENT OPERATION: HOLADAY HI-3550 MAGNETIC FIELD MONITOR	DATE 03/29/05
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1.0 Purpose/Scope

This procedure provides a standardized method for the operation of the Holaday Instrument HI-3550 Magnetic Field Monitor. It should be used in conjunction with the SBMS Subject Area Static Magnetic Fields (SMF) and IH SOP IH-99110 *Static Magnetic Field Measurement Principles: Area Surveys*.

The HI-3550 is used to measure Static magnetic fields (direct current and permanent magnets) and ELF (50/60 Hz) alternating current magnetic fields. This area survey meter is used to determine the baseline and area SMF levels and personnel dosimetry time-weighted average data. It can be used to determine the need for area warning posting, to determine the need for personal monitoring, to sketch isometric lines for control area delineation, and to measure the effectiveness of engineering controls. When used for area surveys, it should be used in conjunction with a paperclip attached to a string to map magnetic force fields that may affect an object. The types of items that can be surveyed with this instrument include static sources such as permanent magnets, Magnetic Resonance Imaging (MRI) equipment, Nuclear Magnetic Resonance (NMR) equipment, superconducting coils, accelerator magnets, detector magnets, dc magnets in radio frequency and microwave tubes, ion pumps, electron microscopes, beam transport magnets, and electromagnetic lifting devices.

This instrument can provide instantaneous and integrated (time weighted) field measurements. It can be operated set so that the instrument will alarm when a preset value is exceeded.

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If the meter reading is to be used to measure the actual employee exposure, then the entire work operation should be observed and information regarding the length of the duration in the field and a description of the procedure including number of times the procedure was performed in the area if it is a repetitive procedure must be documented.

2.0 Responsibilities

- 2.1 **Program Administration:** This procedure is administered through the SHSD Industrial Hygiene Group.
- 2.2 Members of the SHSD Industrial Hygiene Group are required to follow this procedure.
- 2.3 Other BNL organizations that provide BNL with field monitoring or other hazard assessment services are required to follow this SOP or an equivalent document that ensures an equal or superior method of assessment documentation and recordkeeping.
- 2.4 **Industrial Hygiene Professional:** The *Industrial Hygiene Professional* of SHSD and other BNL organizations are to be qualified by their supervision. These individuals will conduct or supervise industrial hygiene hazard assessments and personal exposure monitoring using this procedure. These *IH Professionals* are responsible for:
- Interpreting, reporting, and documenting personal exposure monitoring in accordance with the requirements of this procedure, other appropriate SOPs, and generally accepted professional standards and practices.
 - Ensuring a quality report is prepared that documents the exposure, evaluates the relevance to exposure standards, and recommends protective and corrective actions.
 - Ensuring the final report is provided in a timely manner to all appropriate parties.
 - Ensuring that the appropriate data is correctly and completely entered into the BNL IH exposure monitoring database (i.e. *Compliance Suite*®).
 - Ensuring that original records of sampling and analysis enter the SHSD *Record Custodian* filing system.
- 2.5 **Industrial Hygiene Technician (Sampler):** The industrial hygiene technician is to be qualified by their supervision to conduct industrial hygiene personal exposure monitoring under the direction of his/her organization's *IH Professional*. The sampler is responsible for collecting personal exposure monitoring samples in accordance with the guidance of the *IH Professional* and the requirements of all SOP's pertinent to the

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particular monitoring requirements (i.e. Chain of custody, equipment check in/out, equipment operation, recordkeeping, etc.).

- 2.6 ***Compliance Suite***[®] ***data entry***: The management of the person conducting the sampling is responsible for entering complete and correct data into the BNL IH exposure monitoring database (i.e. *Compliance Suite*). This task may be assigned to one or more individuals who act as the data entry person for an organization, however, it remains the responsibility of the line management of the *Sampler* to ensure this task is fulfilled within 21 calendar days of the end of the sampling event.

3.0 Definitions

- 3.1 *Gauss* (G) – in the CGS system, this the unit for one flux line passing through one square centimeter.
- 3.2 *Magnetic Field* – for static magnetic fields and extremely low frequencies, this is generally used for the magnetic flux density. When referring to RF and microwaves, the term usually means magnetic field strength (H field).
- 3.3 *Magnetic field strength* –(H) vector field () with units of amps per meter.
- 3.4 *Magnetic Flux Density (B) Gauss*: The number of magnetic flux lines per area that is induced by an applied magnetic field intensity H. The B results from an applied H is given by $B = \mu H$, where μ is the permeability (sometimes referred to as the *absolute permeability*) of the magnetic material in which the flux is contained. Where U is zero then $B=H$.
- 3.5 *Magnetic Field Strength or magnetizing force (H)* - The force within the magnet that produces the flux lines.
- 3.6 *Occupational Exposure Limit*: The maximum time weighted average (TWA) or ceiling value exposure permitted for employee exposure, based on the less of the OSHA Permissible Exposure Limits (PEL) or ACGIH Threshold Limit Value (TLV). OSHA does not have a static magnetic field standard. BNL adopted OEL are found in the Static Magnetic Field subject area.
- 3.7 *Tesla* (T)- In the SI system this is 10,000 lines per square centimeter. Unit of magnetic induction or magnetic flux density (B field) in the meter-kilogram-second system (SI) of physical units. One tesla equals one weber per square meter (or magnetic flux per unit area), corresponding to 10^4 gauss

4.0 Prerequisites

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4.1 Training prior to using this meter:

- 4.1.1 Demonstration of proper operation of the instrument to the satisfaction of the employee's supervision.
- 4.1.2 Other appropriate training for the area to be entered (check with ESH coordinator or FR Representative for the facility).
- 4.1.3 Static Magnetic Field Training and review of the subject area *Static Magnetic Fields*.

4.2 Area Access:

- 4.2.1 Contact the appropriate Facility Support Representative or Technician to obtain approval to enter radiological areas.
- 4.2.2 Verify with the appropriate Facility Support Representative or Technician if a Work Permit or Radiological Permit is needed or is in effect. If so, review and sign the permit.
- 4.2.3 Use appropriate PPE for area

5.0 Precautions

5.1 Hazard Determination:

- 5.1.1 The operation of this meter does not cause exposure to any chemical, physical, or radiological hazards. The meter design does not cause significant ergonomic concerns in routine use. The meter does not generate Hazardous Waste.
- 5.1.2 HI-3550 can measure magnetic fields up to 0.3T but will alarm from 0.1-9999.9 mT. High strength magnetic fields can apply strong mechanical forces to the batteries in the HI- 3500 unit.
- 5.1.3 If individuals wear pacemakers, or other medical electronic devices, they may not be exposed to fields greater than or equal to 0.5 mT (5 Gauss) without consultation with the Occupational Medicine Clinic. Also, individuals with ferromagnetic implants should not be exposed to levels greater than or equal to 60 mT (600 G) without clearance from the Occupational Medicine Clinic.

5.2 Personal Protective Equipment/Other Precautions:

- 5.2.1 Areas where the field strength exceeds 10 mT (100G) can cause deletion of information on magnetic memory materials, such as found on credit cards, identification badges, computer disks, and videotapes. Watches may be stopped. These effects have been reported from prolonged exposure to levels as low as 1 mT (10 Gauss).

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- 5.2.2 Use nonmagnetic objects or tools when working with or around magnetic fields above 60 mT. These objects may be drawn into the magnet and pose a flying object hazard. Metal-toed safety shoes may also be affected.
- 5.2.3 Operating temperature range: 0 to 50 C. Do not expose meter to direct sunlight or high temperatures for extended periods.

5.3 **Job Risk Assessment:** Consult the *Job Risk Assessment* below for the hazards and controls of this SOP.

	1	2	3	4	5
Frequency	≤once/year	≤once/month	≤once/week	≤once/shift	>once/shift
Severity	First Aid Only	Medical Treatment	Lost Time	Partial Disability	Death or Permanent Disability
Likelihood	Very Unlikely	Unlikely	Possible	Probable	Multiple

Activity	Hazard	Control(s)	Before Additional Controls					Control(s) Added to Reduce Risk	After Additional Controls					% Risk Reduction	
			Stressor	# of People A	Frequency B	Severity C	Likelihood D		Risk* AxBxCxD	Stressors	# of People A	Frequency B	Severity C		Likelihood D
Taking measurements with direct reading meters	Exposure to NIR fields	Observation of meter reading and maintaining appropriate distance from hazardous levels.	N	1	2	1	3	6							
	Metal object attraction	Use of non-ferrous metal tools, measurements of field strength from low to high strength, signs	N	1	2	2	2	8							
	Exposure to other hazards such as chemicals and ionizing radiation	Follow Work Control Procedures and Radiological Work Permits in the area	N	1	2	2	2	8							

6.0 Procedure

Operation of the HI-3500 (picture of meter and description of controls and displays is contained in Appendix 9.1.)

6.1 **Equipment:** (Pictured in Appendix 9.1)

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- 6.1.1 Meter Body
- 6.1.2 Soft-side carrying case with belt clip
- 6.1.3 One set 4 “AAA” alkaline batteries.
- 6.1.4 Non- magnetic Measuring Stick

6.2 Batteries Installation

- 6.2.1 When not in operation, batteries should be removed. If the machine won't be used for short terms, place the instrument in the standby (**STBY**) mode (switch located on the side of the instrument).
- 6.2.2 Four size AAA batteries power the HI-3550. When the batteries need replacing, the battery indicator appears in the lower right corner of the display. When this appears, replace all four batteries according to the following procedure.
 - Record any integrating measurement data you wish to retain. **NOTE** All stored data is lost when the batteries are removed.
 - Switch the instrument to the instantaneous (ΔB) mode.
 - On the back of the case, locate the battery cover and pull it in the direction of the arrow labeled “OPEN”.
 - Remove the old batteries.
 - Insert new batteries according to the diagrams in the inside of the battery compartment. Reattach the battery cover to the case.
 - After the fourth battery is inserted, the display enters the test state (all display indicators are visible) for approximately 2 seconds. If this does not appear, reinstall the batteries.
 - Make sure that the HI-3550 operates properly in the instantaneous measurement mode (ΔB). If the unit does not operate properly in this mode, the instrument will not measure accurately.

6.3 Measurement Parameters Features:

Setting	Function
Digital display	A measurement occurs every 3 seconds and displays the results on the lower line of the display panel
Measurement Range	The HI-3550 can measure up to 0.3 T for each of the three axes. Depending on orientation of each sensing axis with respect to the direction of the magnetic field, it is possible to display the measured value of field intensities greater than 0.3T. The HI-3550 can display integrated magnetic flux levels of up to 999.99 T-h. Integrated flux levels in excess of this value are not displayed.
Integration mode ($\int B$)	In the integrating mode, the HI-3550 displays elapsed time on the upper line of the display panel. “H” denotes hours, “M” denotes minutes, and “S” denotes seconds. Integrating time is displayed up to 999 hours, 59 minutes, 59 seconds. When the elapsed time exceeds this value, the display rolls over to 0 hours, 00 minutes, 00 seconds, and restarts the count.

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Setting	Function
Peak Hold	<p>The instrument continuously displays the maximum instantaneous value measured since the instrument was last set to the (ΔB) mode. This peak is displayed in the upper line of the display panel.</p> <ul style="list-style-type: none"> - The Maximum peak hold value is 3546.37 mT. - The maximum instantaneous value that is displayed is 3.54 T <p>These readings are also displayed for any measured field strength exceeding these values.</p>
Switching between the Measurement Modes Instantaneous Measurement (ΔB) Mode vs. Integrating (∫B) Mode	<p>Changing the measurement mode from integrating to instantaneous mode will stop the integrating measurement mode while retaining the integrated time and value. After you change the measurement mode the reading will remain unchanged until one measurement cycle (3 seconds) is completed.</p>
(AC) Alternating Magnetic Current) or (DC) Static Magnetic Current).	<p>The proper selection of detection mode is based on the type of field alternating current (AC) or direct current (DC) of the operation or equipment being monitored.</p>

6.3.1 Selecting the Integrating (∫B) Mode

- Slide the <STBY / ∫B / ΔB> switch on the side of the meter to <∫B >.
- Note any previously stored data.
- Erase data as follows <Do not perform this step if you wish to add to previously stored data. > Using the control buttons located on the back of the instrument press the <SELECT> and <SET> buttons simultaneously and hold them for 3 seconds to clear the memory of stored integrated time and value. The alarm settings remain unchanged after the memory is cleared.

6.3.2 Selecting the Instantaneous Measurement (ΔB) Mode

- Slide the <STBY / ∫B / ΔB> switch on the side of the meter to <ΔB >.
- Memory values are cleared. Measurements starts after three seconds.
- When a permanent magnet is placed close to the sensor, the measurement value will vary depending on which axis is nearest to the magnet.

6.3.3 Peak Hold: The instrument continuously displays the maximum instantaneous value measured since the instrument was last set to the (ΔB) mode. To clear the peak hold value, change to any other mode or change the magnetic field selection (AC or DC).

6.3.4 Selecting the magnetic field type detection

- To change the meters ability to detect the target magnet field from a static magnetic field (DC) to an alternating magnetic field (AC), slide

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the <AC-DC> on the side of the meter switch to the desired position <AC> or <DC>.

- NOTE: Be careful to select the appropriate setting for the magnetic field being measured. Incorrect settings can increase the error or uncertainty of the displayed value up to 10%.

6.3.5 Selecting the Stand-by (STBY) Mode: Selecting <STBY> reduces power consumption and prolongs battery life. All stored integrated field data is saved in STBY mode.

- To stop measuring, slide the <STBY / \sqrt{B} / ΔB > switch on the side of the meter to <STBY>.

6.3.6 Alarm Function: Alarm function information is printed in Attachment 8.3.

6.4 Operation of the meter for field measurements:

6.4.1 Slide the power switch <STBY / \sqrt{B} / ΔB > on the side of the meter to either from STBY to either \sqrt{B} or ΔB .

6.4.2 Select the appropriate meter settings from step 6.3.

6.4.3 Operator Position:

- Keep the meter between the source and your body. Approach the source from a safe distance and observe the field strength to avoid over-exposure to the sampler. The operator should be further from the magnetic source than the probe at all times.
- Hold the meter away from the body. Point the meter at the source. The meter has isotropic sensing that measures result regardless of orientation but the sensor should point toward the source. When used as a survey meter, hold meter parallel to the source. Note and record the distance from the source, and location of the measurements.
- When used as a dosimeter, wear on torso at the belt or shirt pocket.

6.5 Recording readings:

6.5.1 Plan and conduct hazard assessments and exposure monitoring using the procedure outlined in *IH 60500 Reporting Personnel Exposure Monitoring Results* for:

- Exposure Assessment Sampling Strategy,
- Initial Notification of Employee Monitoring Results, and
- Preparation of a formal report on the exposure monitoring or hazard assessment.

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- 6.5.2 Use the BNL Direct Reading Sampling Instrument Form found in the SBMS *Static Magnetic Field* Subject Area.
- 6.5.3 If the meter was worn as a dosimeter in the integration mode, record the time of exposure and the recorded time weighted measurement (mT-h).
- 6.5.4 Return meter and original sampling form to the SHSD IH Laboratory daily or at the end of each project as agreed to by the IH Laboratory Technician.
- 6.5.5 Send a copy of any hazard evaluation report written on the survey to the IH Laboratory.
- 6.5.6 If this survey determines that employees are potentially exposed at or above the 0.5 (5 gauss level) for pacemaker users, or above any of the other BNL exposure levels, then identify the employees on the Static Magnetic Field form Part C, Employee Exposure Record, and forward a copy to the IH laboratory and the Occupational Medicine Clinic.

7.0 Implementation and Training

Prior to using this procedure, the user:

- 7.1 Demonstrates proper operation of this instrument to the satisfaction of line supervision or SHSD IH Program Administrator.
- 7.2 Completes other appropriate training for the area to be entered (check with ESH coordinator or FS representative for the facility).
- 7.3 Completes OT&Q Training and a medical surveillance required for any PPE used on the job or for other hazards encountered in the work area.
- 7.4 Completes qualification on this procedure on at least a 3 year basis, providing the professional uses the equipment several times per year.
- 7.5 Personnel are to document their training using the Qualification Criteria listed in *IH51800 Industrial Hygiene Service Delivery Basic Qualification Requirements*.

8.0 References

- 8.1 Holaday 3550 Operating Manual.
- 8.2 BNL SBMS Subject Area – Static Magnetic Fields.

9.0 Attachments

- 9.1 Photo of meter
- 9.2 Short Operating Instructions
- 9.3 Alarm Function

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10.0 Documentation

Document Review Tracking Sheet		
PREPARED BY: <i>(Signature and date on file)</i> N. Bernholc Author Date 07/02/01	REVIEWED BY: <i>(Signature and date on file)</i> J. Peters SHSD IH Group Date 07/02/01	APPROVED BY: <i>(Signature and date on file)</i> R. Selvey SHSD IH Group Leader Date 07/05/01
Filing Code: IH51SR.01	DQAR Date	Effective Date: 07/06/01

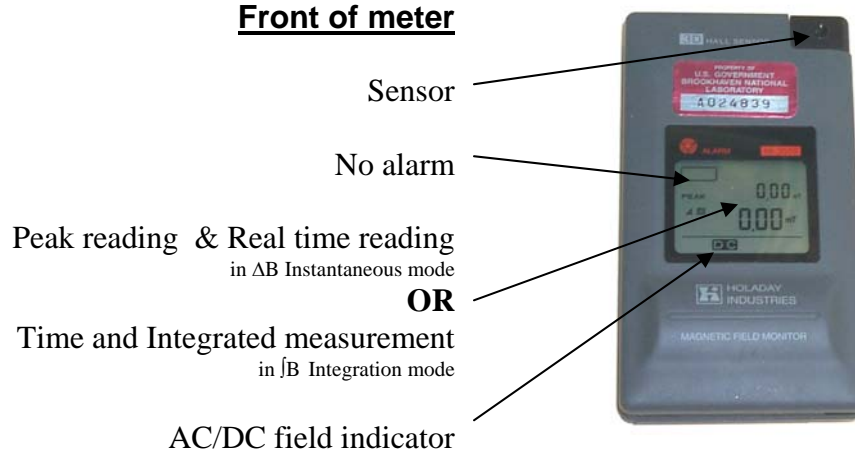
Periodic Review Record		
Date of Review	Reviewer Signature and Date	Comments Attached
03/29/05	<i>(Signature and date on file)</i> R. Selvey 03/29/05	Revised to include Section 7 Implementation and Training. Text added to Section 2, 4,5, 6, and 7. JRA added to Section 5.

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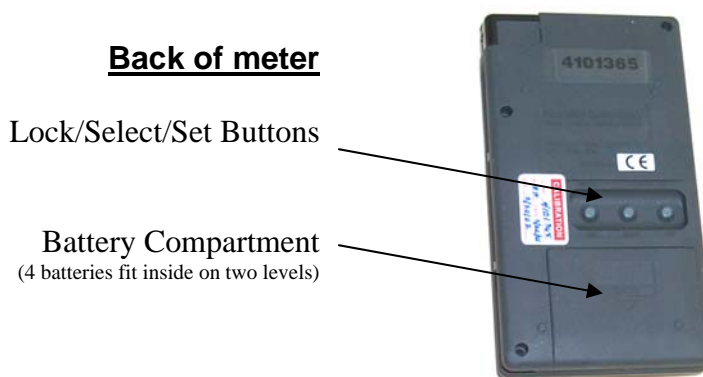
Attachment 9.1

Photo of meter and parts

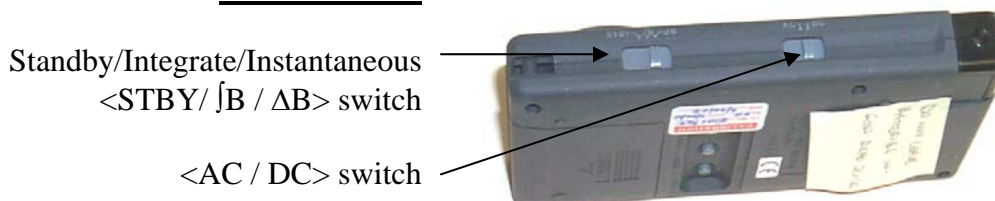
Front of meter



Back of meter



Side of meter



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Attachment 9.2

Short Operating Instructions

	Step	User Action	Digital Display
1	Battery Check	Observe low battery indicator on meter.	If low, the battery indicator flashes in the lower left corner of the display.
2	Start Up	Turn meter from STBY to instantaneous mode (B setting)	Display should have numeric and text messages.
3	Functional Test	In static magnetic field free area (<0.1 mT) place probe near a known source to test that the meter is working.	Displays a numeric response on the meter.
4	Zero the meter	In a magnetic field free area, the meter should read 0.00. Zero cannot be set. If the meter gives a numeric value other than zero, move to another area. If reading remains, record that value as an offset.	Meter should read 0.00
5a	Operation as direct reading meter for Area Surveys (Instantaneous Display)	<ul style="list-style-type: none"> Select DC mode for static fields Select instantaneous function (the ΔB) Point probe at source- a measurement cycle is 3 seconds. This reading is displayed for any measured field strength exceeding this value. The maximum instantaneous value is 3546.37 mT (3.54 T) 	PEAK 0.00 mT ΔB 0.00 mT DC or AC
5b	Operation as a Dosimeter (Integrated measurement)	<ul style="list-style-type: none"> Select DC mode for static fields or AC for alternating fields Select integrating mode ($\int B$) Place meter on torso The elapsed time indicator shows up to 999 hours, 59 minutes, 59 seconds. After that time the display rolls over and restarts. The integrated measurements show up to 999.99T-h. Integrated flux in excess of this value are not displayed. 	H M S TIME 00 00 00 $\int B$ 0.00 mT-h
5c	Peak Hold Display Range	This reading is displayed for any measured field strength exceeding this value. The peak range is 3546.37 mT	PEAK 0.00 mT ΔB 0.00 mT
6	Clearing Peak hold value	Change to any other mode, such as momentarily changing the magnetic field selection from AC to DC.	PEAK 0.00 mT ΔB 0.00 mT
7	Clearing Integrated Values	Press the SELECT and SET buttons found on the back of the instrument simultaneously for approximately 3 seconds	H M S TIME 00 00 00 $\int B$ 0.00 mT-h

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Attachment 9.3

Alarm Function

1 Selecting Alarm Mode

- 1.1 Slide the measurement Mode switch to STBY.
- 1.2 Press LOCK button for 3 seconds. The alarm display will be indicated on the LCD readout.

2 Activating/Deactivating the Alarm

- 2.1 When the alarm set mode is initiated, the word OVER appears and the alarm symbol blinks the alarm is on; when it disappears, the alarm is off. When it deactivated, no alarm sounds even is an alarm value has been programmed.

3 Setting the Instantaneous Alarm Value

- 3.1 After the alarm mode is activated, press the SELECT button.
- 3.2 The alarm set symbol is visible, the word OVER disappears and both the ΔB AL-SET indicator and the instantaneous measurement units (mT) appear.
- 3.3 The most significant digit of the instantaneous measurement value is blinking.
- 3.4 The instrument is now ready to be set to the desired alarm value for the instantaneous measurement mode.
- 3.5 Each time the SET button is pressed, the value of the reselected digit increments by one.
- 3.6 Press SET until the selected digit indicates the desired value.
- 3.7 Each time you press the SELECT button, the digit to be programmed advances to the right.
- 3.8 Set each digit, to set the next alarm value desired. NOTE: PROCEEDING TO THE NEXT STEP MAKES THE ΔB AL-SET mark goes out and the leading zeros of the instantaneous alarm value are suppressed. For example 0050.0 is displayed as 50.0
- 3.9 After you program all digits of the alarm value, pressing the SELECT button will switch the instrument into the integrated alarm units-of –measurement program.
- 3.10 The ΔB AL-SET indicator and the digits to be programmed appear in the lower line of the display and the integrating unit of measure blinks.
- 3.11 Pressing the SET button now toggles the units of measurement between mT-h and T-h (milliTesla-hours and Tesla-hours).

4 Setting the Integrating Alarm Value

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- 4.1 After doing the above, press SELECT button.
- 4.2 Each time the SET button is pressed, the value of the selected digit increments by one.
- 4.3 Press SET until the selected digit indicates the desired value.
- 4.4 Each time you press the SELECT button, the digit to be programmed advances to the right.
- 4.5 Set each digit, to set the next alarm value desired.
- 4.6 After you have programmed all of the values, pressing SELECT returns the instrument to the alarm ON/OFF state.
- 4.7 When you return to the alarm ON/OFF state the integrating B AL-SET mark will go out
- 4.8 As before, leading zeros will be suppressed.
- 5 **Turning alarm on/off**
 - 5.1 The alarm is toggled on and off each time you press the SET button.
 - 5.2 The alarm is on when the alarm symbol is visible.
- 6 **Stopping the Integrating Mode alarm.**
 - 6.1 Press lock, select, or set buttons. When the alarm is interrupted in this manner, the over indicator appears.
 - 6.2 The integrating alarm will not operate again until reset.
- 7 **Clearing a manually interrupted alarm**
 - 7.1 Press select and set buttons simultaneously for 3 seconds clears the memory of integrated time and value but will also reset the alarm.
 - 7.2 Therefore, record the values on the dosimeter before resetting the alarm.
- 8 **Alarm meanings**
 - 8.1 The instantaneous alarm signal occurs 8 times per second for a duration of three seconds
 - 8.2 The integrating alarm signal occurs once per second for duration of 60 seconds.
 - 8.3 The integrating alarm signal is produced only in the integrating measurement mode.